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(54) **CHARGING PORT DEVICE FOR ELECTRIC VEHICLE**

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(52) **U.S. Cl.**

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(58) **Field of Classification Search**

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USPC ..... 439/304, 310, 133

See application file for complete search history.

(56) **References Cited**

U.S. PATENT DOCUMENTS

8,075,329 B1 \* 12/2011 Janarthanam et al. .... 439/304  
8,251,734 B2 \* 8/2012 Katagiri et al. .... 439/352

(Continued)

FOREIGN PATENT DOCUMENTS

JP 2010-264847 A 11/2010  
JP 2011-81952 A 4/2011

(Continued)

OTHER PUBLICATIONS

The Korean Office Action for the corresponding Korean Application No. 10-2015-7002629 issued on Mar. 5, 2015.

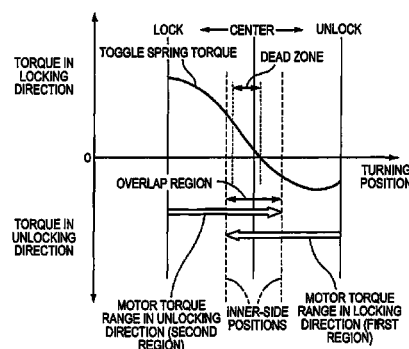
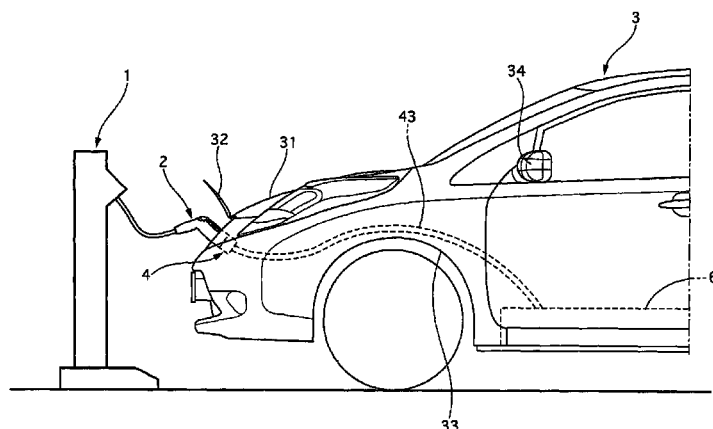
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(57) **ABSTRACT**

A charging port device for an electric vehicle has an electrical driving mechanism for electrically applying a torque using a motor to move a restricting member to an inner-side position short of a predetermined position corresponding to a locked state or an unlocked state, and a mechanical driving mechanism for mechanically applying a torque to move the restricting member from the inner-side position to the predetermined position, when the restricting member is to be moved to the predetermined position, and a part of the restricting member overlaps the engaging member, when viewed from the direction of separation, at the inner-side position that corresponds to a movement to the locked state.

**15 Claims, 8 Drawing Sheets**



(56)

**References Cited**

## U.S. PATENT DOCUMENTS

8,357,001	B2 *	1/2013	Katagiri et al. ....	439/304
8,376,768	B2 *	2/2013	Kurumizawa et al. ....	439/304
8,523,589	B2 *	9/2013	Kurumizawa et al. ....	439/304
8,698,349	B2 *	4/2014	Kurumizawa et al. ....	307/10.1
8,753,136	B2 *	6/2014	Hirashita et al. ....	439/304
2011/0281452	A1 *	11/2011	Kurumizawa et al. ....	439/304
2014/0235086	A1 *	8/2014	Nakajima .....	439/347
2014/0235087	A1 *	8/2014	Nakajima .....	439/347
2014/0235089	A1 *	8/2014	Nakajima .....	439/350

2014/0300319	A1 *	10/2014	Nakajima .....	320/109
2014/0300320	A1 *	10/2014	Nakajima .....	320/109
2015/0035478	A1 *	2/2015	Uchiyama et al. ....	320/107
2015/0037994	A1 *	2/2015	Nakajima .....	439/304

## FOREIGN PATENT DOCUMENTS

JP	2011-165609	A	8/2011
JP	2011-238530	A	11/2011
JP	2011-243498	A	12/2011

\* cited by examiner

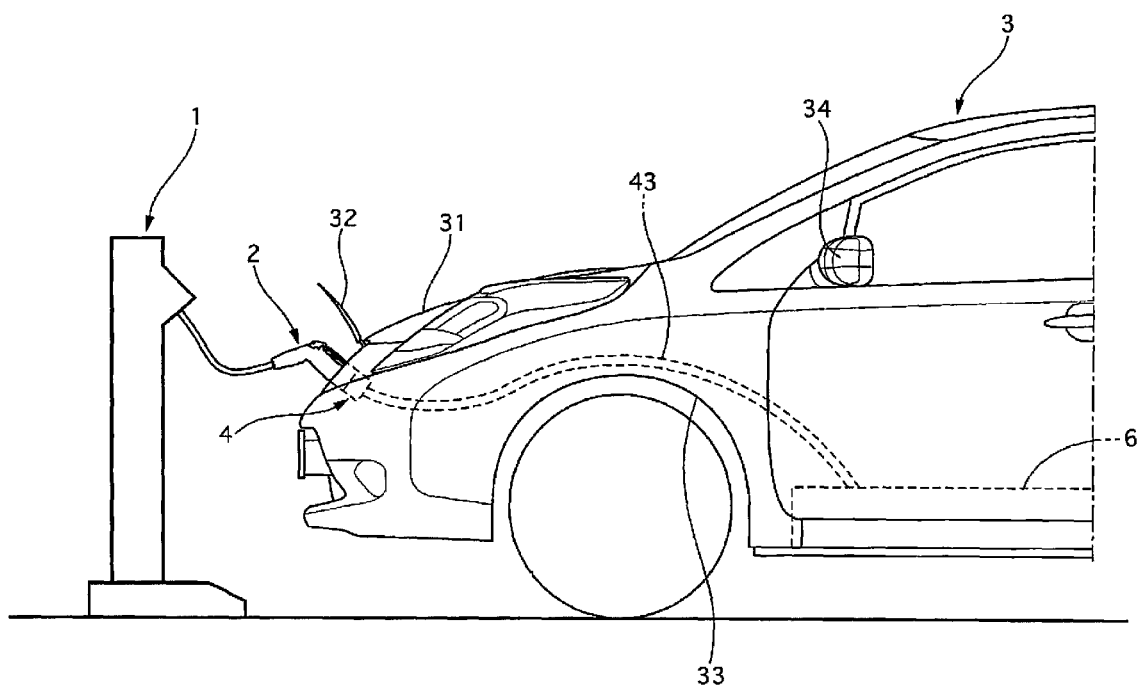


FIG. 1

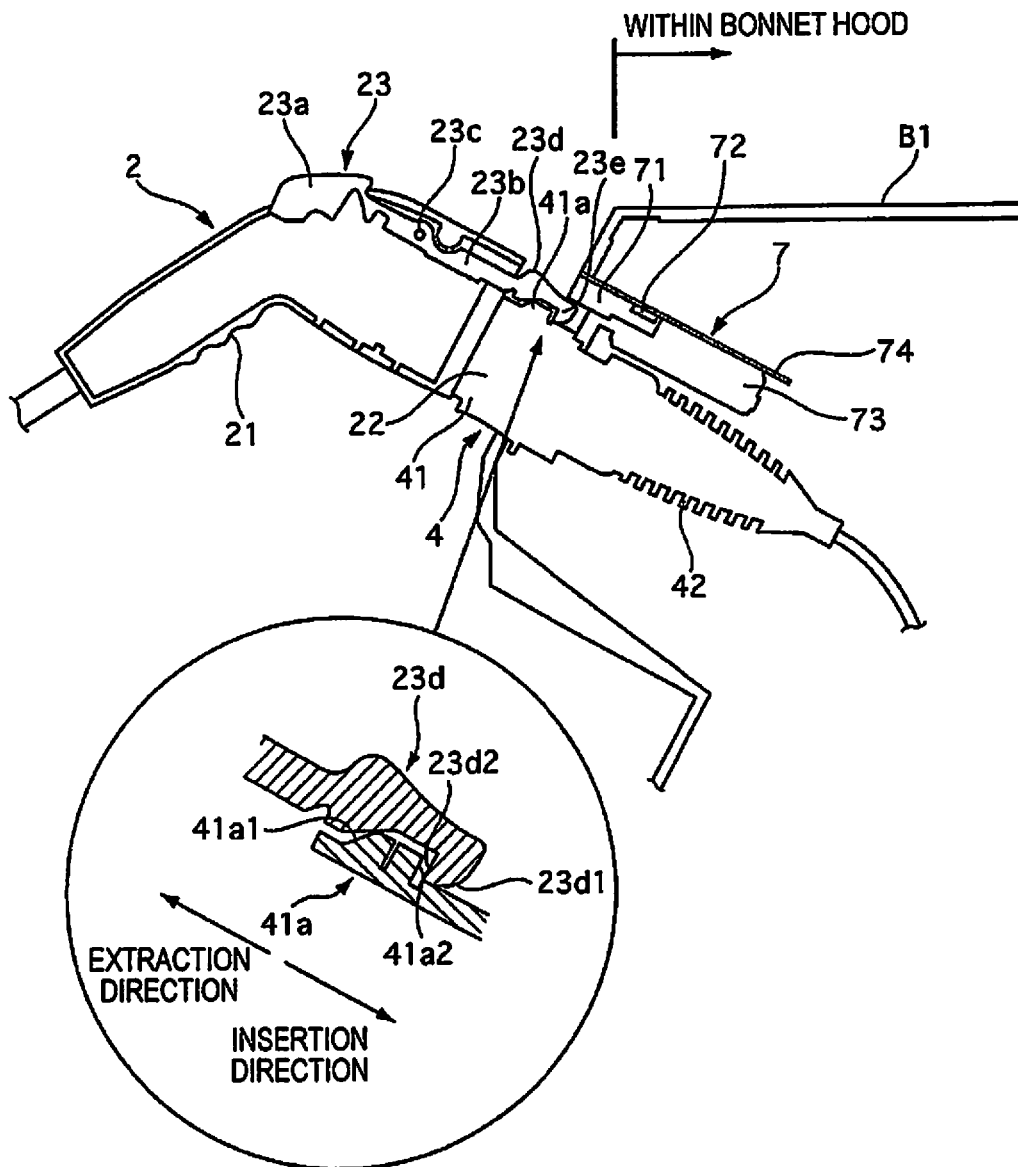


FIG. 2

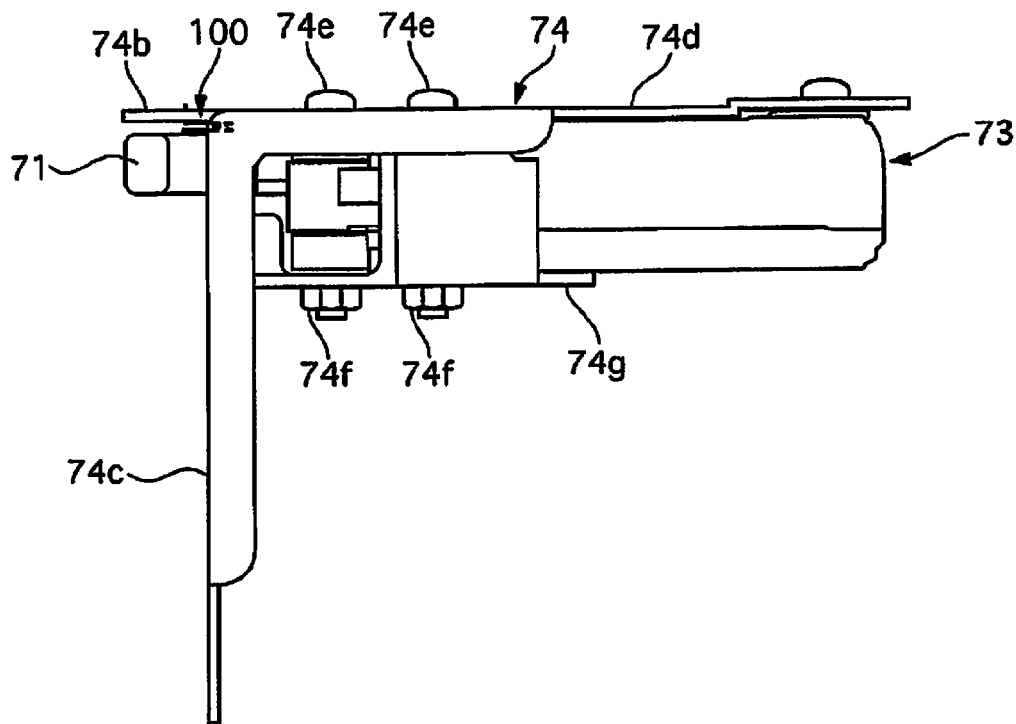


FIG. 3

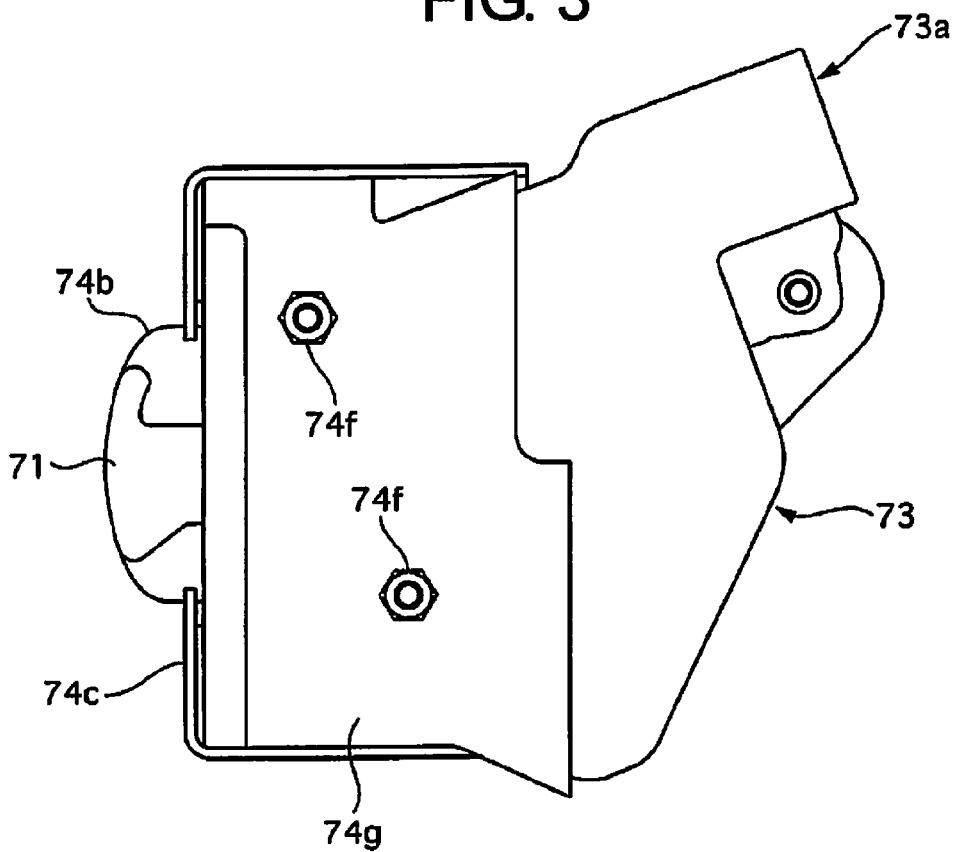


FIG. 4

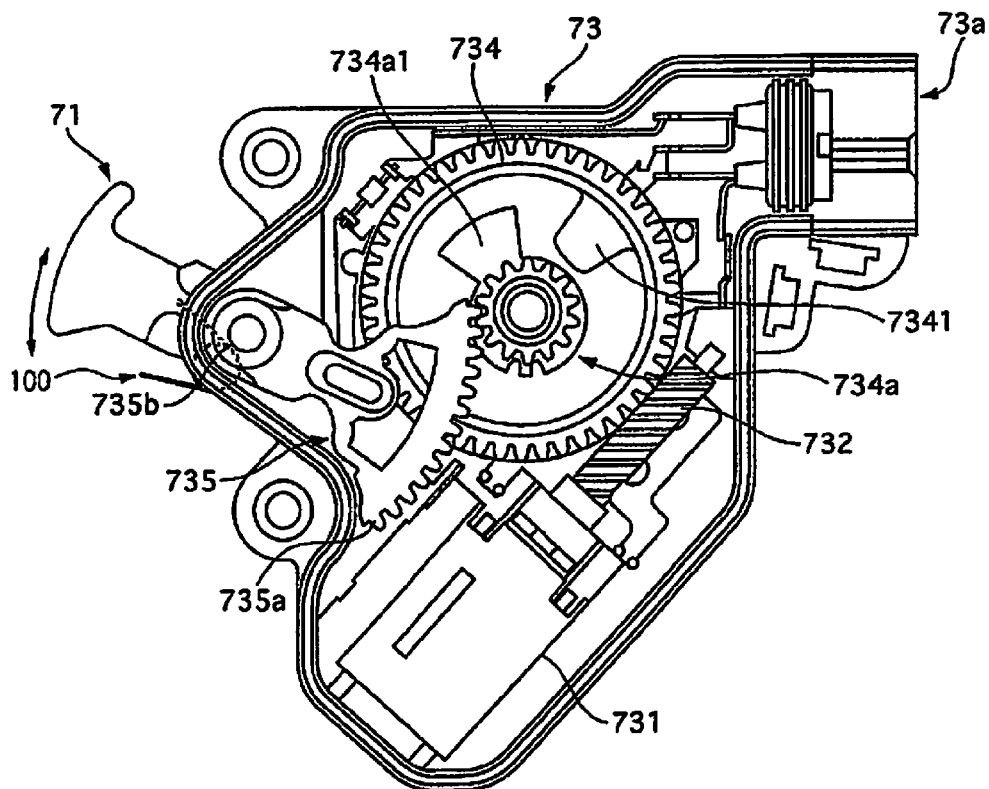


FIG. 5

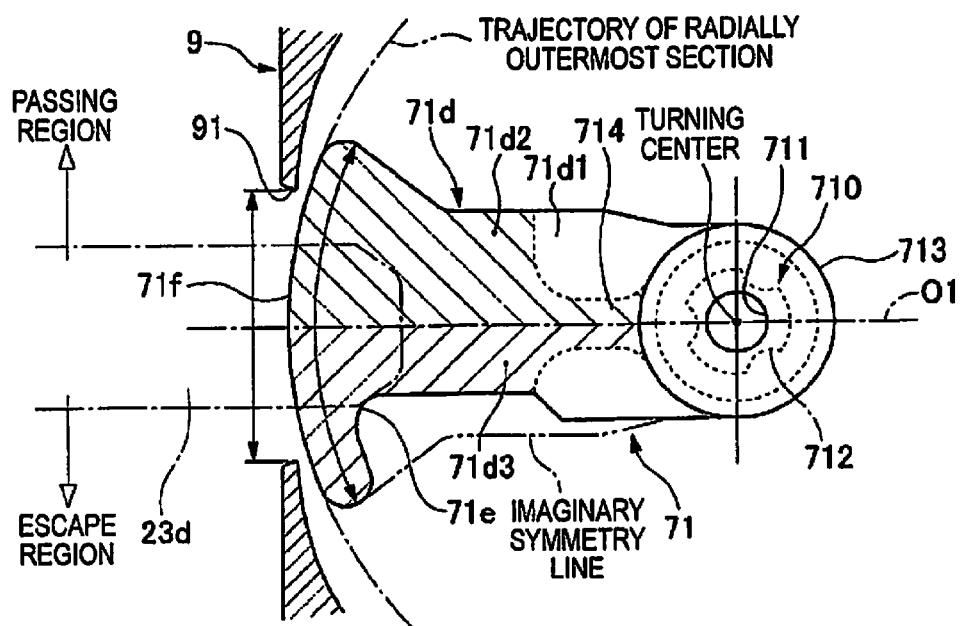


FIG. 6

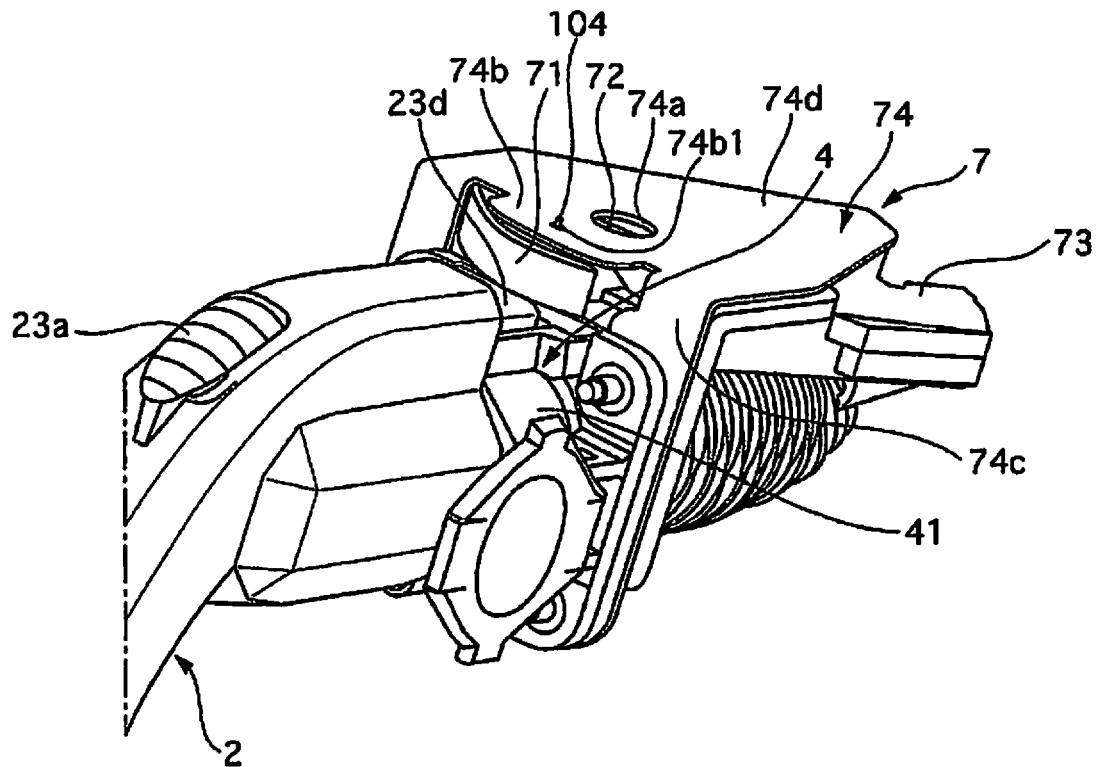


FIG. 7

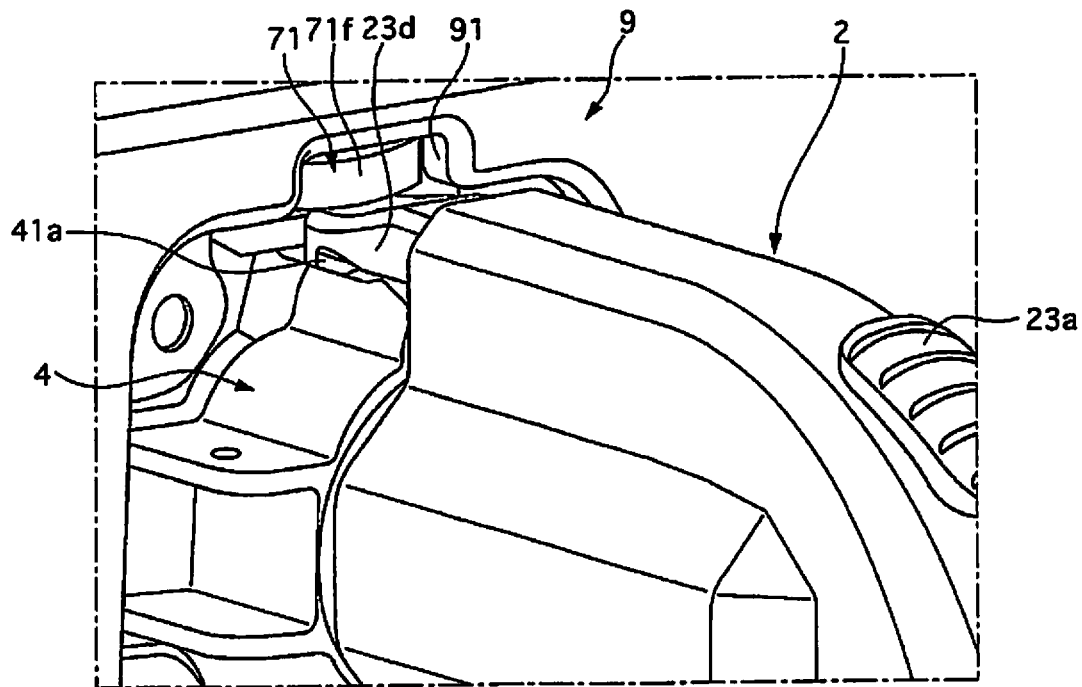


FIG. 8

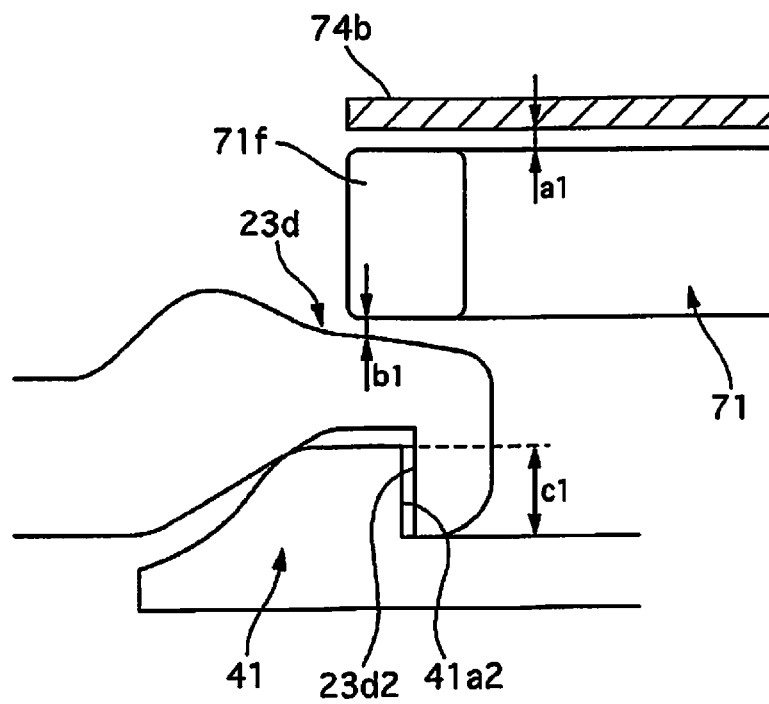


FIG. 9

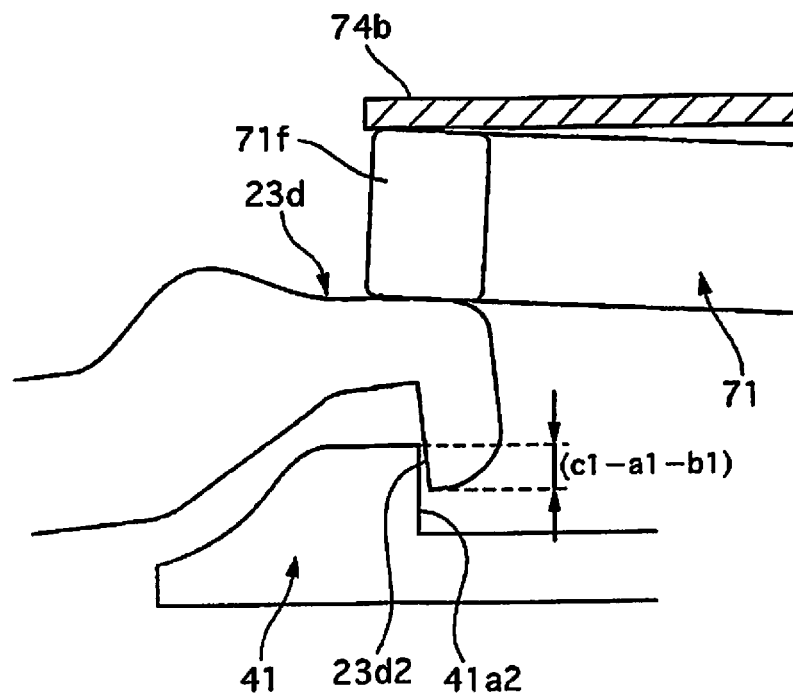


FIG. 10



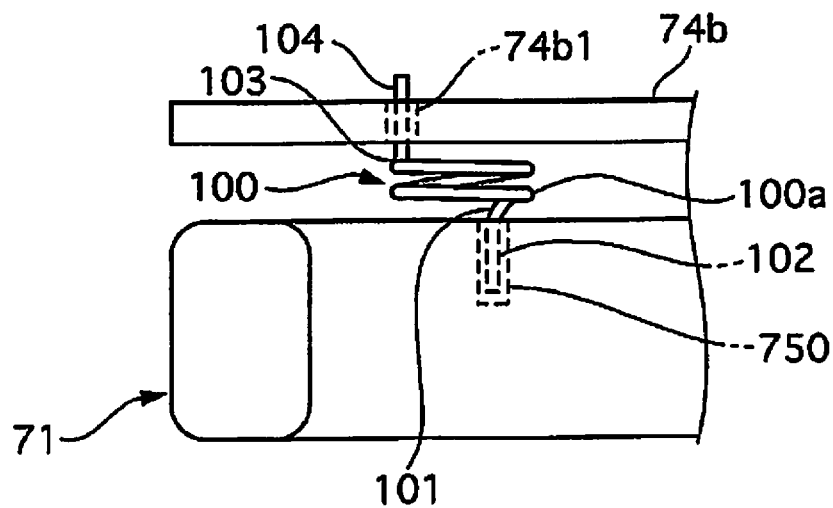


FIG. 11

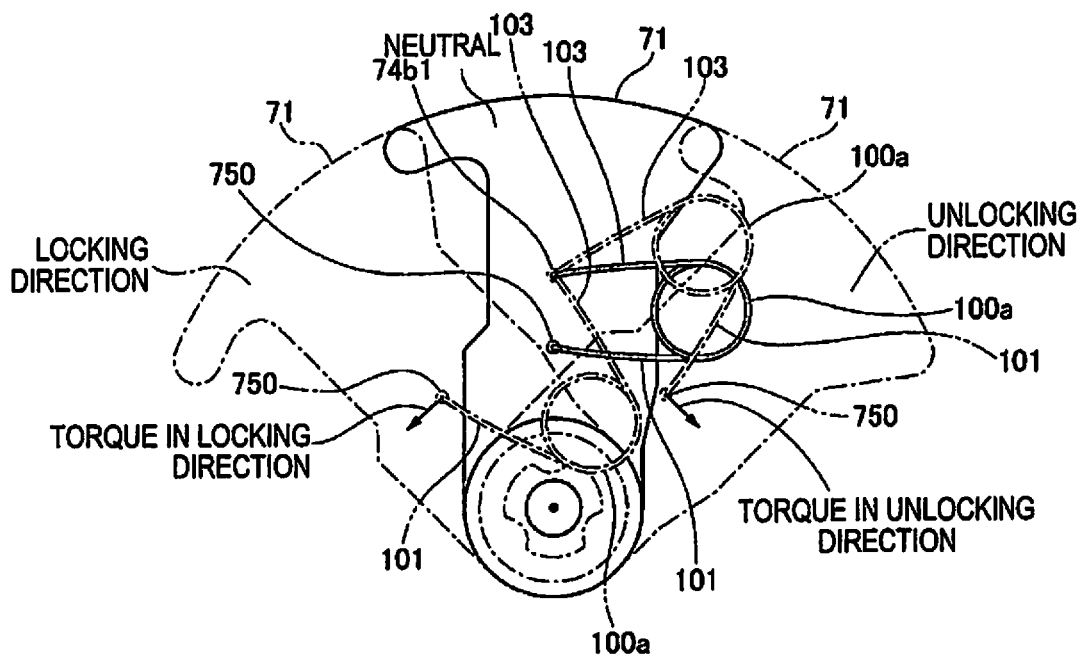


FIG. 12

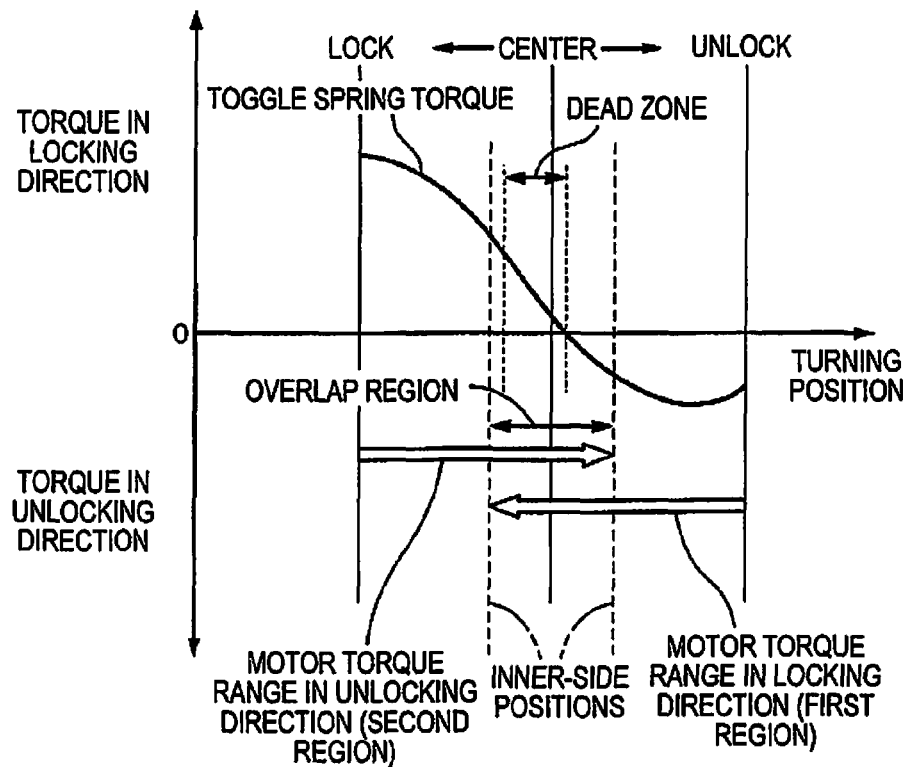


FIG. 13

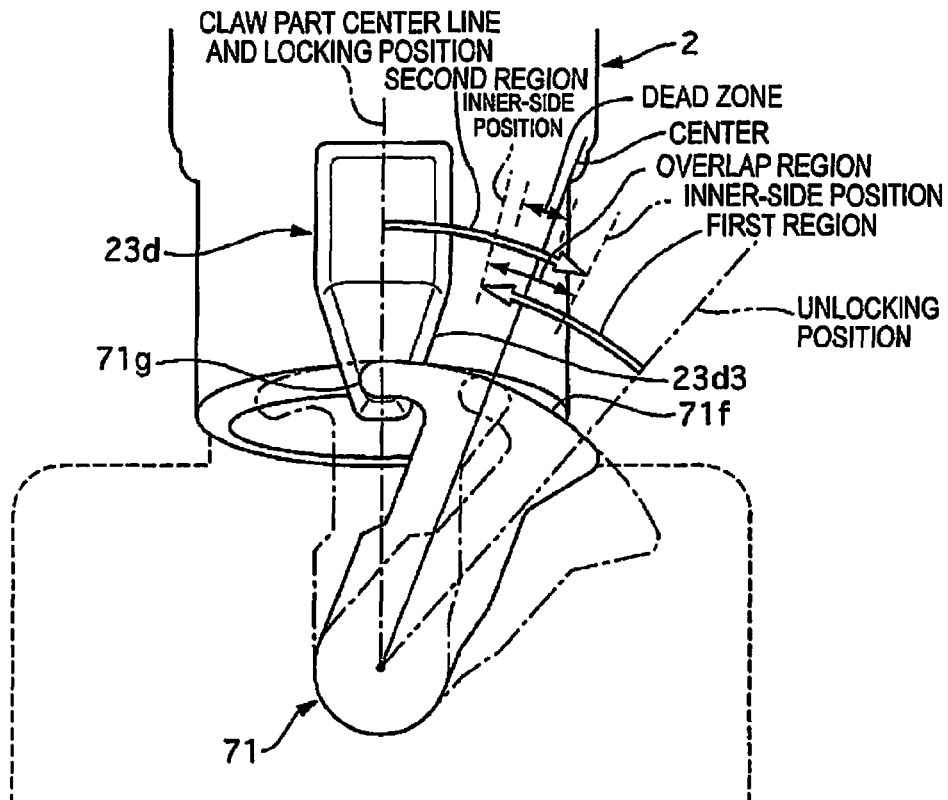


FIG. 14

1

## CHARGING PORT DEVICE FOR ELECTRIC VEHICLE

### CROSS-REFERENCE TO RELATED APPLICATIONS

This application is a U.S. National stage application of International Application No. PCT/JP2013/065538, filed Jun. 5, 2013, which claims priority to Japanese Patent Application No. 2012-150972 filed in Japan on Jul. 5, 2012, the contents of each of which are hereby incorporated herein by reference.

### FIELD OF THE INVENTION

The present invention relates to a charging port device for charging a battery mounted in an electric vehicle.

### BACKGROUND INFORMATION

Japanese Laid-Open Patent Application No. 2010-264847 discloses a technique relating to a charging port device for an electric vehicle. In particular, Japanese Laid-Open Patent Application No. 2010-264847 discloses a charging connector for connecting a charging port of an electric vehicle and a charging stand representing power supply means or device. The charging connector has a link **41** that is capable of turning with a button operation performed by the operator so as to enable coupling, and the charging connector engages a protrusion **34** in a charging inlet **11**, thereby preventing the charging connector and the charging inlet from detaching from each other during charging. Also disclosed is a configuration having a slide-type lock bar (hereafter referred to as a lock mechanism) for disabling the link **41** from rotating in order to prevent the removal and theft of the charging cable during charging.

### SUMMARY

When the abovementioned lock mechanism is actuated by a motor, a configuration in which the motor and the lock bar are continuously coupled results in excessive load being applied to the motor, the link mechanism, and similar elements, presenting a problem in terms of durability.

In view of the abovementioned problem, an object of the present invention is to provide a highly durable charging port device for an electric vehicle in which a charging port and a charging connector can be prevented from unexpectedly disconnecting from each other.

In order to achieve the above objective, in a charging port device for an electric vehicle according to the present invention, when charging is performed using a charging connector having an engaging member, it is possible to switch between a locked state and an unlocked state through a movement of a restricting member. The charging port device for an electric vehicle has an electrical driving mechanism for electrically applying a torque using a motor to move the restricting member to an inner-side position short of a predetermined position corresponding to the locked state or the unlocked state, and a mechanical driving mechanism for mechanically applying a torque to move the restricting member from the inner-side position to the predetermined position, when the restricting member is to be moved to the predetermined position, and a part of the restricting member overlaps the engaging member, when viewed from the direction of separation, at the inner-side position that corresponds to a movement to the locked state.

2

Thus, because the motor is not used to move the restricting member across the entire actuation range of the restricting member, it is possible to prevent an excessive load from being applied on the restricting member, improving durability. It is also possible to obtain an unlocked state at the inner-side position, i.e., within the range of actuation of the electrical driving means, making it possible to enhance the reliability of the restricting means.

### BRIEF DESCRIPTION OF THE DRAWINGS

Referring now to the attached drawings which form a part of this original disclosure:

FIG. **1** is a schematic diagram showing a state in which an electric vehicle with a charging port device according to a first embodiment is being charged;

FIG. **2** is a schematic cross-sectional view showing a state in which a charging port and a charging connector of the first embodiment are connected;

FIG. **3** is a side view showing the configuration of a lock mechanism according to the first embodiment;

FIG. **4** is a bottom view showing the configuration of the lock mechanism according to the first embodiment;

FIG. **5** is an internal structural diagram showing the mechanical configuration of the lock mechanism according to the first embodiment;

FIG. **6** is a top view showing the configuration of the swing arm of the lock mechanism according to the first embodiment;

FIG. **7** is a schematic perspective view of a state in which the charging connector and the charging port according to the first embodiment are connected;

FIG. **8** is a perspective view showing a state in which the charging connector and the charging port according to the first embodiment are connected;

FIG. **9** is a schematic cross-sectional view showing the positional relationship between the engaging member and the swing arm according to the first embodiment;

FIG. **10** is a schematic cross-sectional view showing the positional relationship between the engaging member and the swing arm according to the first embodiment when the engaging member is unduly actuated in the direction of separation;

FIG. **11** is a schematic diagram illustrating a portion provided with the toggle spring according to the first embodiment;

FIG. **12** is a schematic view showing the mechanical operation of the toggle spring according to the first embodiment;

FIG. **13** is a diagram showing the positional relationship between the swing arm and the action ranges of torques from the toggle spring and the motor according to the first embodiment; and

FIG. **14** is a top-view schematic diagram showing the positional relationship between the engaging member and the swing arm according to the first embodiment.

### DETAILED DESCRIPTION OF EMBODIMENTS

#### Embodiment 1

FIG. **1** is a schematic diagram showing an electric vehicle with a charging port device according to a first embodiment being charged. A charging port **4** is electrically connected by a cable **43** to an automotive battery **6** mounted on a floor of a vehicle **3**, and is disposed on the front of the vehicle **3**, further forward than the hood **31**. The charging port **4** is disposed at a position that is substantially the same height as an upper end of tire wheel arches **33** and lower than that of side mirrors **34**,

3

and is closed by a charge lid 32 when not charging. A charging connector 2 for supplying power is disposed on a charging stand 1. When charging is to be performed, the charge lid 32 is opened and the charging connector 2 is connected by inserting the charging connector 2 into the charging port 4, whereby charging can be performed. The vehicle according to the first embodiment includes both a rapid charging port, used when connecting to a rapid charger, and a normal charging port, used when charging using domestic power or the like. In the first embodiment, a description of the normal charging port as an example will be provided, because when the rapid charging port is used, the connection time is relatively short, and it is rare for connection to the port to be left for a long period of time. It shall be apparent that a lock mechanism may also be disposed on the rapid charging port.

FIG. 2 is a schematic cross-sectional view showing the charging port and the charging connector of the first embodiment connected. The charging port 4 has: an insertion receiving member 41, which is fixed on the vehicle side to a body-constituting member B1 interposed by a bracket 74, the charging connector 2 being inserted into the insertion-receiving member 41; the cable 43 connected to the insertion-receiving member 41 inside the vehicle body; and a tube 42 for coating a connection part of the cable 43. A convex part 41a (engaged part) is formed on the outer periphery of the insertion-receiving member 41, and an insertion hole, into which an insertion part 22 can be inserted only in a predetermined positional relationship, is formed in the inner periphery of the insertion-receiving member 41.

The charging connector 2 is of generally a type that is commonly installed and is a standardized product for which the format and size are stipulated by a unified standard. The charging connector 2 is connected by an operator to the charging port 4 of the vehicle. The charging connector 2 has a grip section 21 to be gripped by the operator, the insertion part 22 inserted into the charging port 4 on the vehicle side, and an engaging member 23 which can be engaged and released with respect to the charging port 4 by the operator. The engaging member 23 engages the convex part 41a disposed on the charging port 4 side when the charging connector 2 is connected to the charging port 4 and thereby regulates movement in the direction in which the charging connector 2 is extracted from the charging port 4.

The engaging member 23 is a member that turns about a support point 23c fixed against a case member of the charging connector 2. The engaging member 23 is urged by an elastic body (not shown) so that a release button 23a is positioned higher in FIG. 2 (i.e., so that a claw part 23d is positioned lower in FIG. 2). The release button 23a, which the operator can press while gripping the grip section 21, is present at a grip section 21-side end section of the charging connector 2. The claw part 23d, which engages with the convex part 41a, is present at an insertion part 22-end section of the charging connector 2. The claw part 23d has a claw shape in which a distal end portion has: a curved section 23d1 having a curved surface which is smooth with respect to the direction of insertion; and a stepped section 23d2 which is acutely angled with respect to the direction of extraction. A sloped surface 41a1 is formed on an end surface representing the outer side with respect to the vehicle body of the convex part 41a, and an engaging surface 41a2, which is substantially perpendicular to the direction of extraction, is formed on an end surface representing the inner side with respect to the vehicle body of the convex part 41a, forming an anisotropic convex shape.

When the charging connector 2 is inserted into the charging port 4, the curved section 23d1 at the distal end portion of the claw part 23d is able to pass over the sloped surface of the

4

convex part 41a without any particular operation being performed on the release button 23a. Once the stepped section 23d2 passes the engaging surface 41a2, the action of the elastic body (not shown) pushes the claw part 23d downwards, and the claw part 23d and the convex part 41a engage with each other. The charging connector 2 may also be inserted while pressing the release button 23a. The stepped section 23d2 and the engaging surface 41a2 thereby engage, regulating movement in the direction of extraction even if the operator pulls the charging connector 2 in the direction of extraction without operating the release button 23a. In order to release the engagement, the release button 23a is pushed inwards to turn the engaging member 23 about the support point 23c and move the claw part 23d above the engaging surface 41a2, whereby the engagement is released.

FIG. 3 is a side view showing the configuration of a lock mechanism according to the first embodiment, and FIG. 4 is a bottom view showing the configuration of the lock mechanism according to the first embodiment.

The lock mechanism 7 for restricting the turning movement of the engaging member 23 is provided above the charging port 4. The lock mechanism 7 has: a swing arm 71, which produces, by being positioned in a direction in which the claw part 23d separates away from the convex part 41a, a state of restricting the separation (hereafter referred to as a "locked state"), and produces, by not being positioned in a direction in which the claw part 23d separates away from the convex part 41a, a state of not restricting the separation (hereafter referred to as an "unlocked state"); a lock actuator 73 for driving the swing arm 71; and the bracket 74 for fixing and supporting the insertion-receiving member 41 of the charging port 4 and the lock actuator 73.

As can be seen in the side view shown in FIG. 3 and the bottom view shown in FIG. 4, the bracket 74 has: an upper surface section 74d, which fixes and supports the lock actuator 73 using bolts 74e; a support extension section 74b, which extends from the upper surface section 74d so as to cover the mobility range of the swing arm 71; a side surface section 74c, which is folded at a substantially right angle with respect to the upper surface section 74d, the insertion-receiving member 41 and similar elements being attached to the side surface section 74c by a bolt; and a cover member 74g, which is attached from the side opposite that of the upper surface section 74d, the cover member 74g and the upper surface section 74d sandwiching the lock actuator 73. The upper surface section 74d, the lock actuator 73, and the cover member 74g are integrally assembled by a plurality of bolts 74e and nuts 74f. An opening 74a for forcible operation following failure, through which a fixing screw 72 (described further below) can be operated, is formed on the upper surface section 74d (see FIGS. 2 and 7, etc.); the operator is able to open the bonnet hood and turn the fixing screw 72 using a screwdriver or a similar tool. The reason for this will be described further below. A toggle spring 100 for assisting the movement of the swing arm 71 is disposed between the support extension section 74b and the swing arm 71. The toggle spring 100 applies a torque, from a position nearer the center than that which the swing arm 71 is in a locked state, towards the position at which the swing arm 71 is in a locked state. Similarly, the toggle spring 100 applies a torque, from a position nearer the center than that at which the swing arm 71 is in an unlocked state, towards the position at which the swing arm 71 is in an unlocked state. Details of the toggle spring 100 will be described further below.

FIG. 5 is an internal structural diagram showing the mechanical configuration of the lock mechanism according to the first embodiment. The lock actuator 73 has: a connector

5

unit 73a which connects to an external power supply and a controller; a motor 731 which is rotationally driven on the basis of a command signal; a worm 732, which rotates integrally with the rotor of the motor 731; a worm wheel 734, which engages with the worm 732 and rotates; a drive gear 734a, which has a smaller diameter than that of the worm wheel 734 and the same rotation axis as that of the worm wheel 734, and which rotates relative to the worm wheel 734; and a driven member 735, which engages with the drive gear 734a and has a toothed surface on the outer periphery. A partially raised engaging convex part 7341 is provided on a board surface of the worm wheel 734. An engaged part 734a1 extending in a substantially fan-shape is formed on the outer diameter of the drive gear 734a. When the worm wheel 734 rotates, the engaging convex part 7341 also turns. In such an instance, when the engaging convex part 7341 and the engaged part 734a1 are in a non-engaged state, the drive gear 734a does not turn. When the engaging convex part 7341 and the engaged part 734a1 engage, the drive gear 734a thereby begins to turn. This operation acts in the same way whether the worm wheel 734 rotates clockwise or counterclockwise in FIG. 5.

The first embodiment is configured so that the swing arm 71 is turned by the torque (corresponding to an electrical driving mechanism) from the motor 731 to an inner-side position short of that at which the swing arm 71 is in a locked or an unlocked state, and is turned thereafter, i.e., to the position at which the swing arm 71 is in a locked or an unlocked state, by the torque from the toggle spring 100 (corresponding to a mechanical driving mechanism). At this point, the driven member 735 is turned further by the torque from the toggle spring 100. At this point, the engaged part 734a1, which is actuated integrally with the driven member 735, turns away from the engaging convex part 7341 of the worm wheel 734 which is actuated integrally with the motor 731. Therefore, the action of the motor 731 does not affect this turning motion. A configuration of such description makes it possible to readily turn the swing arm 71 when the swing arm 71 is turned and released by manual operation, even when a fault develops in the motor 731 and the motor 731 is no longer able to perform the rotational driving operation. The relationship with the toggle spring 100 will be described further below.

The driven member 735 has a substantially fan-shaped meshing part 735a having a toothed surface formed on the outer periphery, and a turning shaft section 735b assembled with the swing arm 71 so as to be integral. The swing arm 71 is a member which actuates so that the turning shaft section 735b functions as a turning axis. In other words, the swing arm 71 has a turning axis oriented in a direction different from the direction in which the charging connector 2 is inserted and extracted and different from the direction of the turning axis of the engaging member 23. The lock mechanism of the first embodiment requires the swing arm 71 to actuate only within a predetermined angular range; therefore, using a driven member 735 having a toothed surface on a partial portion thereof makes it possible to perform actuation with sufficient torque even when the motor 731 is small. A lock actuator 73 of such description is also employed in common automotive auto-door-lock and similar mechanisms, and components of such mechanisms can be transferred for use in order to reduce production cost.

FIG. 6 is a top view showing the configuration of the swing arm of the lock mechanism according to the first embodiment. The swing arm 71 has an attaching section 710, which is attached to the turning shaft section 735b of the lock actuator 73 so that the attaching section 710 and the turning shaft

6

section 735b do not rotate relative to each other, and a cylindrically shaped cylindrical wall 713 covering the outer circumference of the attaching section 710. Recesses 712 are formed at three locations on the circumference of the attaching section 710. Convex parts formed on the turning shaft section 735b side fit into the recesses 712, whereby relative rotational movement is regulated. A through hole 711 is formed at the center of the attaching section 710, and is penetrated by the fixing screw 72 for integrally fixing the swing arm 71 and the turning shaft section 735b to each other. The through hole 711 puts the upper part of the swing arm 71 and the lock actuator 73 side in communication with each other, and as a result, in an instance in which freezing or the like hinders the actuation of the swing arm 71 and hot water is applied to defrost the frozen state, the through hole 711 also functions as a passage for channeling the hot water, making it possible to promptly defrost the frozen state. The fixing screw 72 is screwed to a female screw part disposed on the turning shaft section 735b side, whereby the turning shaft section 735b and the swing arm 71 actuate integrally.

The direction in which the fixing screw 72 is tightened is the same direction as that in which the swing arm 71 turns in the unlocking direction. This is in order to make it possible, even when the lock actuator 73 fails or develops another problem and becomes completely unable to perform a release movement, to turn the swing arm 71 in the release direction by tightening the fixing screw 72.

FIG. 7 is a schematic perspective view of a state in which the charging connector and the charging port according to the first embodiment are connected. With reference to FIGS. 7 and 2, the fixing screw 72 is formed so as to be exposed in the opening 74a for forcible operation following failure and inside the bonnet hood. In order to open the hood, normally, a hood release lever in the vehicle compartment is operated. The fixing screw 72 is located at a position that can be readily accessed as long as the release lever can be operated, or, in other words, at a position that cannot be accessed by opening the charge lid 32. The fixing screw 72 is thereby formed so that a stranger who has no access to the vehicle compartment is not able to operate the fixing screw 72 unauthorized. The fixing screw 72 can also be readily operated using a cross-head screwdriver or a similar tool available, e.g., as an automotive tool, allowing the operator to perform the release operation.

A plate-shaped arm member 71d extends from the cylindrical wall 713 leftwards in FIG. 6. The arm member 71d is designed so as to expand at a distal end in a fan shape and overlap with the claw part 23d in top view (corresponding to being positioned in the direction of separation of the engaging member). A lightened section 71d1 for reducing weight and a rib 714 for providing sufficient strength are formed on the arm member 71d.

The swing arm 71 is formed from a resin, and formed so as to be vertically asymmetrical in top view as shown in FIG. 6. Using an axis O1, which links the turning center of the swing arm 71 (i.e., the point at which the turning axis of the swing arm 71 and the center of the swing arm 71 in the thickness direction coincide) and the turning center of the engaging member 23 in the locked state (i.e., the point at which the turning axis of the engaging member 23 and the center of the engaging member 23 coincide), as a reference line in top view, an imaginary symmetry line representing vertical symmetry is indicated by a dotted line, and a description will now be given on the basis of a relationship with the imaginary symmetry line. The portion below the axis O1 is, in other words, a region corresponding to the swing arm 71 escaping when shifting from a restricting state of the lock mechanism

to a non-restricting state. Accordingly, the region below the axis O1 is defined as an escape region, and the region above the axis O1 is defined as a passing region.

If the swing arm 71 is symmetrical between the escape region and the passing region, the area of the region that is located further on the escape region side than the claw part 23d will be larger. In such a case, the following problem is presented. Since the charging port 4 is provided at a relatively low position on the vehicle, when another vehicle passes nearby, there may be cases in which sherbet-like snow, muddy water, or similar matter is kicked up and splashed onto the charging port 4. In addition, when charging is performed in an extremely low-temperature environment, there may be cases in which the splashed sherbet-like snow or muddy water freezes, forming icicle-like obstacles hanging off the arm member 71d of the swing arm 71 which acts as a roof. In such a case, if the region of the arm member 71d in the escape region is larger, the icicle-shaped obstacles or the like form more readily, and a risk is presented in that even when an unlocking command is outputted, the obstacles on the swing arm 71 and the claw part 23d catch on each other, preventing unlocking.

Therefore, the arm member 71d is cut away significantly from the imaginary symmetry line to the vicinity of the claw part 23d. In other words, the area 71d3 of the arm member 71d present in the escape region (i.e., the top-view area on the side of the direction in which the swing arm 71 is turned to a restricting state, in relation to a line linking the turning center of the claw part 23d and the turning center of the swing arm 71 when positioned in the direction of separation of the claw part 23d) is smaller than the area 71d2 of the arm member 71d present in the passing region (i.e., the top-view area on the side of the direction in which the swing arm 71 is turned to a non-restricting state, in relation to the line linking the turning center of the claw part 23d and the turning center of the swing arm 71 when positioned in the direction of separation of the claw part 23d). The portion acting as a roof in the escape region can be thereby made smaller, making it less likely for icicle-shaped obstacles or the like to form, therefore making it possible to smoothly actuate the swing arm 71 during unlocking. In particular, cutting away the arm member 71d to the limit of the region that overlaps the claw part 23d in top view makes it possible to further reduce the possibility of obstacles or the like forming while restricting the movement of the claw part 23d in the direction of separation in a reliable manner.

Next, a radially outermost section 71f of the swing arm 71 is shaped, in top view, so as to be symmetrical about the reference line, which is the axis O1. Specifically, in envisioning a situation in which, when the swing arm 71 is turned by actuation of the lock actuator 73, the swing arm 71 does not sufficiently turn due to a failure or another problem, ensuring that the swing arm 71 is still positioned in the direction of separation of the claw part 23d will be more reliable if the radially outermost section 71f has a sufficient length.

FIG. 8 is a perspective view showing a state in which the charging connector and the charging port according to the first embodiment are connected. When the charging connector 2 is inserted into the charging port 4, the lock mechanism 7 is actuated, and the swing arm 71 is positioned in the direction of separation of the claw part 23d, the claw part 23d cannot be moved in the separation direction even when the release button 23a is pressed. The convex part 41a and the claw part 23d are thereby prevented from disengaging, and the charging connector 2 is prevented from being extracted. A cover member 9 for providing protection against entry of dirt and the like into the lock mechanism 7 and other structures is

provided to the charging port 4 of the vehicle. The cover member 9 covers the lock mechanism 7 from the side of the direction in which the charging connector 2 is inserted and extracted, and has an opening 91 into which the claw part 23d can be inserted and in which a part of the swing arm 71 is exposed.

When the operator inserts the charging connector 2 into the charging port 4, actuates the lock mechanism 7, leaves the location, and starts charging, the radially outermost section 71f of the swing arm 71 is in an exposed state as shown in FIG. 8. If the gap between the cover member 9 and the radially outermost section 71f is larger, it will be possible to insert a finger or an object into the gap and forcibly pry open the swing arm 71. Therefore, the gap between the swing arm 71 and the cover member 9 is set to be narrow, without there being any contact.

In a state in which the lock mechanism 7 is restricting the removal of the charging connector 2, the entirety of the opening 91 is closed by the radially outermost section 71f of the swing arm 71. In other words, the length of the radially outermost section 71f in the direction of turn is greater than the opening width (i.e., the length in the direction of turn) of the opening 91. This is to prevent the possibility of a gap being present between an end section of the opening 91 and an end section of the swing arm 71 and the swing arm 71 being forcibly pried open by inserting a finger or an object into such a gap as described above.

A description will now be given, with reference to FIG. 6, for the relationship between the cover member 9 and the swing arm 71. As shown in FIG. 6, the gap between an inner peripheral surface of the cover member 9 and the trajectory of the radially outermost section 71f when the swing arm 71 performs a turn is set so as to expand with increasing distance from the opening 91. Specifically, in a case in which the charging connector 2 is connected to the charging port 4 in a state in which the dirt or the like (e.g., chewing gum, mud, dust clumps, etc.) is adhered to the claw part 23d, the turning motion of the swing arm 71 is performed while scraping off (sweeping) the dirt. If the gap between the inner peripheral surface of the cover member 9 and the trajectory of the radially outermost section 71f is set so as to gradually narrow, there is a risk of the scraped-off dirt getting trapped in the gap, generating a large resistance and preventing the actuation of the swing arm 71. Therefore, the gap between the inner peripheral surface of the cover member 9 and the trajectory of the radially outermost section 71f is set so as to expand with increasing distance from the opening 91, whereby the scraped-off dirt falls downwards in an appropriate manner, preventing dirt blockages or similar problems.

FIG. 9 is a schematic cross-sectional view showing the positional relationship between the engaging member and the swing arm according to the first embodiment. A predetermined gap a1 is present between an upper surface of the swing arm 71 and the support extension section 74b, and a predetermined gap b1 is also present between a lower surface of the swing arm 71 and the claw part 23d. Accordingly, when the swing arm 71 turns, the swing arm 71 does not come into contact with the support extension section 74b or the claw part 23d, allowing the swing arm 71 to actuate in a smooth manner. When the height of a region in which the stepped section 23d2 and the engaging surface 41a2 overlap when viewed from the direction in which the charging connector 2 is inserted and extracted is represented by c1, a configuration is present so that the relationship  $c1 > (a1 + b1)$  is satisfied. Accordingly, even if the claw part 23d is unduly forced

upwards and the gaps *a1*, *b1* are eliminated as shown in FIG. 10, the stepped section *23d2* and the engaging surface *41a2* remain engaged.

FIG. 10 is a schematic cross-sectional view showing the positional relationship between the engaging member and the swing arm according to the first embodiment when the engaging member is unduly actuated in the direction of separation. When the release button *23a* is pressed inwards in a state in which the lock mechanism *7* is actuating and the movement of the engaging member *23* in the direction of separation is restricted, an upper surface of the claw part *23d* comes into contact with the lower surface of the swing arm *71* and presses the swing arm *71* upwards. The swing arm *71* is made of a resin, and the turning shaft section *735b* of the lock actuator *73* is also not designed to be excessively firm; therefore, the swing arm *71* is readily pushed upwards due to deformation or a tilt in the turning axis. However, the support extension section *74b* is provided, and therefore contact with the support extension section *74b* suppresses further deformation. In addition, because a force only acts in the thickness direction of the swing arm *71*, sufficient strength against a compressive force can be obtained even when the swing arm *71* is made of a resin. Specifically, the turning axis of the swing arm *71* is oriented in a different direction from the direction in which the charging connector *2* is inserted and extracted, and also from the direction of the turning axis of the engaging member *23*. In other words, the orientation of the turning axis of the swing arm *71* and the orientation of the turning axis of the engaging member *23* are not in a parallel relationship, the swing arm *71* is interposed in the direction of separation of the claw part *23d* to provide restriction, and the support extension section *74b* is further provided. As a result, even when an undue force is inputted from the claw part *23d*, the force does not act in the direction of turn of the swing arm *71*; therefore, a sufficient restricting state can be maintained without the need to reinforce the swing arm *71* in the direction of turn or the need to reinforce the structure in the vicinity of the turning axis.

The action of the toggle spring will now be described. FIG. 11 is a schematic diagram illustrating a portion provided with the toggle spring according to the first embodiment, FIG. 12 is a schematic view showing the mechanical operation of the toggle spring according to the first embodiment, and FIG. 13 is a characteristic diagram showing the positional relationship between the swing arm and the action ranges of torques from the toggle spring and the motor according to the first embodiment. The horizontal axis represents the turn position of the swing arm *71*, and indicates a position in the locked state (hereafter referred to as the locked position), a position in the unlocked state (hereafter referred to as the unlocked position), and a center position therebetween. The vertical axis represents the torque acting on the swing arm *71*. The upper vertical axis represents the toggle spring torque acting in the locking direction and the lower vertical axis represents the toggle spring torque acting in the unlocking direction.

As shown in FIG. 11, the toggle spring *100* has: a coil section *100a* for generating an elastic force; a swing arm side foot section *101* extending from the coil section *100a* and engaging with the swing arm *71*; and an insertion section *102* obtained by bending the swing arm side foot section *101* in a substantially right angle, the insertion section *102* being turnably inserted in an engaging hole *750* formed in the swing arm *71*. Similarly, the toggle spring *100* has: a vehicle body side foot section *103* extending from the coil section *100a* and engaging with the support extension section *74b*; and an insertion section *104* obtained by bending the vehicle body side foot section *103* in a substantially right angle, the inser-

tion section *104* being turnably inserted in an engaging hole *74b1* formed in the support extension section *74b*.

A description will now be given in correspondence with a top schematic view shown in FIG. 12. FIG. 11 is a schematic view as viewed from the lateral direction when the swing arm *71* is in a neutral position, and the corresponding top view configuration is illustrated in the portion of FIG. 12 corresponding to the neutral position. At this time, the toggle spring *100* is in a bent state. At this point, the toggle spring *100* acts so as to push the foot sections *101*, *103* apart. However, the force acts radially with respect to the turning center of the swing arm *71*, and does not act in a direction in which the swing arm *71* is caused to turn. When the swing arm *71* is turned by the motor *731* in the locking direction from this state, the coil section *100a* displaces downwards in FIG. 12. The force from the toggle spring *100* acting to push the foot sections *101*, *103* apart is thereby imparted with a component that acts to cause the swing arm *71* to rotate in the locking direction, and the resulting torque urges the swing arm *71* towards the locked position. Similarly, when the swing arm *71* is turned by the motor *731* in the unlocking direction, the coil section *100a* displaces upwards in FIG. 12. The force from the toggle spring *100* acting to push the foot sections *101*, *103* apart is thereby imparted with a component that acts to cause the swing arm *71* to rotate in the unlocking direction, and the resulting torque urges the swing arm *71* towards the unlocked position.

Thus, it can be seen, by looking at the relationship between the turning motion of the swing arm *71* and the operation of the toggle spring *100*, that the toggle spring *100* undergoes a movement in a gap between the swing arm *71* and the support extension section *74b*. Because this movement generates friction, a predetermined dead zone is produced in the toggle spring *100* in both directions centered on a position at which the engaging hole *74b1* and the engaging hole *750* are aligned in a single line with the turning center of the swing arm (hereafter referred to as the spring center position). In other words, the toggle spring *100* must turn by a certain amount from the spring center position before being able to generate a turning direction torque capable of overcoming friction.

The relationship between the action of the toggle spring and the motor operation will now be described in further detail using the diagram in FIG. 13 and a top-view schematic view showing the positional relationship between the engaging member and the swing arm in FIG. 14. The top view as referred to in the first embodiment is substantially equivalent to viewing from the direction in which the claw part *23d* separates from the engaging surface *41a2*. As described with respect to the lock mechanism, the motor *731* moves the swing arm *71* to an inner-side position short of the locked position or the unlocked position. The range in which the motor torque is outputted is, with regard to the region in which the torque acts in the locking direction, a range extending from the unlocked position, over the center, and up to a predetermined locking region (hereafter referred to as a first region), and with respect to the region in which the torque acts in the unlocking direction, a range extending from the locked position, over the center, and up to a predetermined unlocking region (hereafter referred to as a second region). Because the toggle spring *100* has a dead zone, if the operation of the motor *731* stops within the dead zone, the toggle spring force will not be able to move the swing arm *71*. Therefore, when the motor *731* is operated, the swing arm *71* is always driven beyond the dead zone of the toggle spring *100*. In other words, the motor *731* is controlled so that the first region and the second region overlap. The dead zone of the toggle spring *100* is formed at a position that overlaps the region in which the

## 11

first region and the second region overlap. It is thereby possible to move the swing arm 71, using the torque from the toggle spring 100, to the locked position or the unlocked position.

A description will now be given for the positional relationship between the swing arm 71 and the claw part 23d when the swing arm 71 moves from the unlocked position to the locked position. As shown in FIG. 14, if the swing arm 71 has turned up to the "inner-side position" forming the first region, the swing arm 71 and the claw part 23d overlap in top view. In other words, when a torque is electrically applied by the motor 731, which is an electrical driving mechanism, and the swing arm 71 is moved to the "inner-side position," a top-view side end part 71g, which is a part of the swing arm 71, overlaps the claw part 23d when viewed from the direction of separation. When the swing arm 71 has turned to the "inner-side position," the top-view side end part 71g of the swing arm 71 is positioned further towards the locking side than the center line of the claw part, and at the "inner-side position," the radially outermost section 71f of the swing arm 71 overlaps the claw part 23d at least by half, in terms of the length in the direction of turn, when viewed from the direction of separation.

In addition, in the first embodiment, the turn position of the swing arm 71 is such that the top-view side end part 71g of the swing arm 71 is positioned further towards the locking side than the center line of the claw part at the "center position" (position further towards the unlocking side than the "inner-side position") shown in FIG. 14. In other words, at the "center position" further towards the unlocking side than the "inner-side position," the radially outermost section 71f still overlaps the claw part 23d at least by half when viewed from the direction of separation.

In addition, when the swing arm 71 has turned from the unlocked position to a "dead zone start position" which is further towards the unlocking side than the "center position," the top-view side end part 71g of the swing arm 71 has similarly turned to a position beyond the center line of the claw part 23d (see FIG. 14) towards the locking side.

Specifically, in the first embodiment, from the viewpoint of, e.g., improving the durability, a first region in which a torque is electrically applied using the motor 731 and a region in which a torque is mechanically applied using the toggle spring 100 are formed. As a result, because the motor is not used to move the swing arm 71 across the entire actuation range of the swing arm 71, the swing arm 71 is configured so that an excessive load is prevented from being applied on the motor and other elements, improving durability, and an urging force is applied at a predetermined position using the toggle spring 100, whereby the predetermined position is consistently maintained.

If, when the swing arm 71 has reached a region in which actuation is performed by the toggle spring 100 only, there is no engagement at all between the swing arm 71 and the claw part 23d, i.e., there is no overlapping at all when viewed from the direction of separation, there will be a complete reliance on the elastic force from the toggle spring 100 to produce a locked state. However, there may be instances in which a small torque is unable to sufficiently move the swing arm 71 due to problems such as contamination (by dirt, mud, or the like) or formation of ice in colder regions. If there is a complete reliance on the elastic force from the toggle spring 100 in such an instance, there is a risk of it not being possible to obtain a sufficient turning motion, raising concerns about the reliability of the locking movement.

In contrast, a configuration in which the swing arm 71 and the claw part 23d overlap in top view before the end of the first

## 12

region in which a reliable torque can be electrically applied using the motor 731 makes it possible to obtain sufficient reliability in the locking movement and improve both the durability and reliability.

The dead zone is set to a region offset towards the locking side from the center position of the swing arm 71. In other words, the dead zone is formed at a position such that there is more overlap in the region on the locking side of the neutral position than in the region on the unlocking side of the neutral position. A specific dead-zone-offsetting method will now be described. In order to facilitate description, the above description for FIG. 12 was given for a spring center position, at which the engaging hole 74b1 and the engaging hole 750 are aligned in a single line with the turning center of the swing arm at the neutral position. Forming this spring center position so as to be slightly offset towards the locking side makes it possible to offset the dead zone. Thus, offsetting the dead zone to the locking side makes it possible to secure an unlocked state in a more reliable manner.

The reason for securing the unlocked state will now be described. While the vehicle is basically stationary, no particular vibrations or other movements are inputted, and the swing arm 71 is unaffected. Therefore, when the vehicle is in a stationary state such as during charging, maintaining a locked state is not difficult. In contrast, while the vehicle is traveling, a vibration or another movement can be transmitted. Therefore, if a vibration having the resonance frequency of the swing arm 71 is transmitted, there is a risk of the swing arm 71 moving to a locked state despite being set to an unlocked state. In such an instance, when the operator parks the vehicle at a charging stand and attempts to charge the battery, because the swing arm 71 is in a locked state, it will not be possible to insert the charging connector 2. Because the operator is not expecting to operate the lock mechanism in particular, such a situation will be unexpected. Therefore, reliably securing an unlocked state even when a vibration or another movement is transmitted while the vehicle is traveling prevents the operator from experiencing the unexpected situation.

As described above, the first embodiment has the following effects.

(1) The charging port device for an electric vehicle has: a charging port 4 having a convex part 41a (engaged part) which is engaged with an engaging part of a charging connector 2 by an operation performed by a user, power from an external power supply being supplied to the charging port 4 in an engaged state; a swing arm 71 (restricting member) that, when a claw part 23d (engaging part) and the convex part 41a are in an engaged state, regulates a release operation in which the claw part 23d separates from the convex part 41a, restricting the engaged state from being released; and a lock mechanism 7 (locking state control means) for moving the swing arm 71 by powered driving and thereby producing a locked state, in which there is an overlap with the claw part 23d when viewed from the direction of separation and the release operation on the claw part 23d is regulated, and an unlocked state, in which there is no overlap with the claw part 23d and the release operation is allowed; the lock mechanism 7 having an electrical driving mechanism for electrically applying a torque using a motor 731 to move the swing arm 71 up to an inner-side position short of a predetermined position corresponding to the locked state or the unlocked state, and a toggle spring 100 disposed between the swing arm 71 and the vehicle body side (a mechanical driving mechanism for mechanically applying a torque to move the swing arm 71) from the inner-side position to the predetermined position, when the swing arm 71 is to be moved to the predetermined



13

position; and a part of the swing arm 71 overlapping with the claw part 23d, when viewed from the direction of separation, at the inner-side position that corresponds to a movement to the locked state.

As a result, because the motor is not used to move the swing arm 71 across the entire actuation range of the swing arm 71, the swing arm 71 can be prevented from applying an excessive load on the motor and other elements, making it possible to improve durability. In addition, because the swing arm 71 is moved by the toggle spring 100, an urging force can be applied to a predetermined position, making it possible to consistently maintain the predetermined position. Furthermore, because the swing arm 71 and the claw part 23d overlap at a position at which a torque can be applied electrically, it is possible to obtain sufficient reliability in the locking movement.

(2) The radially outermost section 71f of the swing arm 71 overlaps the claw part 23d, at least by half, when viewed from the direction of separation, at the inner-side position. A locked state can thereby be reliably secured at a position at which a torque can be electrically applied, making it possible to improve reliability.

(3) The lock mechanism 7 has a dead zone in which the swing arm 71 is not moved by the spring force from the toggle spring 100, and the radially outermost section 71f of the swing arm 71 overlaps the claw part 23d, when viewed from the direction of separation, in the dead zone.

It is thereby possible to secure a locked state even when it is not possible to actuate the swing arm 71 in the dead zone.

(4) The lock mechanism 7 controls the motor 731 so that there is an overlap between a first region, in which the torque from the motor 731 acts when the swing arm 71 is moved to the locked state, and a second region, in which the torque from the motor 731 acts when the restricting member is moved to the unlocked state; and the dead zone in which the swing arm 71 is not moved by the spring force from the toggle spring 100 is formed at a position that overlaps a region in which the first region and the second region overlap.

It is thereby possible to apply a torque electrically using the motor 731 in the dead zone, making it possible to actuate the swing arm 71. Outside the dead zone, the swing arm 71 can be moved by the torque from the toggle spring 100 to the locked position or the unlocked position.

(5) A toggle spring 100 is provided as the mechanical driving mechanism. It is thereby possible to apply an urging force solely to a desired region using a simple configuration, and to produce a stable actuation at low cost.

(6) The restricting member is a swing arm which switches between the locked state and the unlocked state by turning. It is thereby possible to maintain a sufficient restricting state using a simple configuration. It is also possible to transfer components employed in existing auto-door-lock and similar mechanisms for use in order to reduce production cost.

The present invention has been described above on the basis of an embodiment; however, other configurations are also possible. In the first embodiment, an example was given in which the present invention is a charging port disposed on the front of the vehicle; however, the invention may be disposed on the rear or a side of the vehicle. In addition, although a description was given in the embodiment with regard to an electric automobile, the present invention can also be used in a plug-in hybrid vehicle or another vehicle.

In addition, in the first embodiment, an example was given for a configuration in which a coil spring is used as the toggle spring; however, there is no problem in applying another configuration having the same effect. For example, the urging force may be applied using a see-saw-type toggle switch. In

14

addition, in embodiments described above, a description was given for an example in which a switch is made between a restricting state and a non-restricting state by a turning motion. However, the switch is not limited to one that is made by a turning motion, and a configuration in which a switch is made by a structure that slides longitudinally or laterally is also possible. Furthermore, in the embodiment, the claw part center line and the locked position are situated at the same position as shown in FIG. 14; however, the locked position may be situated at a position at which a further turn has been performed, or at a position located slightly towards the inner side.

The invention claimed is:

1. A charging port device for an electric vehicle, comprising:

a charging port having an engaged part configured to engage an engaging part of a charging connector, the charging port being configured to receive power from an external power supply when the engaging part and the engaged part are in an engaged state;

a restricting member that, when the engaging part and the engaged part are in the engaged state, regulates a release operation in which the engaging part separates from the engaged part, so as to restrict the engaged state from being released; and

a locking state control device configured to move the restricting member to produce a locked state and an unlocked state, the locked state being a state in which the engaged part and the engaging part overlap when viewed from a direction of separation and in which the release operation on the engaging part is restricted, the unlocked state being a state in which there is no overlap between the engaged part and the engaging member and in which the release operation is enabled,

the locking state control device having an electrical driving mechanism and a mechanical driving mechanism,

the electrical driving mechanism being configured to electrically impart a torque using a motor to move the restricting member to an inner-side position, the inner-side position being different from a predetermined position, the predetermined position corresponding to one of the locked state and the unlocked state,

the mechanical driving mechanism being configured to mechanically impart a torque to move the restricting member from the inner-side position to the predetermined position, and

the restricting member including a part configured to overlap the engaging part when viewed from the direction of separation while the restricting member produces the locked state and is disposed at the inner-side position near the predetermined position when the predetermined position corresponds to the locked state.

2. The charging port device for an electric vehicle according to claim 1, wherein

the restricting member is configured to overlap the engaging member at least by half its length, when viewed from the direction of separation, at the inner-side position near the predetermined position corresponding to the locked state.

3. The charging port device for an electric vehicle according to claim 2, wherein

the locking state control device has a dead zone in which the restricting member is not moved by the mechanical driving mechanism, and the restricting member overlaps the engaging member, when viewed from the direction of separation, in the dead zone.

15

4. The charging port device for an electric vehicle according to claim 2, wherein

the mechanical driving mechanism is a toggle spring disposed between the restricting member and a vehicle body side.

5. The charging port device for an electric vehicle according to claim 2, wherein

the restricting member is a swing arm configured to switch between the locked state and the unlocked state by turning.

6. The charging port device for an electric vehicle according to claim 1, wherein

the mechanical driving mechanism is a toggle spring disposed between the restricting member and a vehicle body side.

7. The charging port device for an electric vehicle according to claim 6, wherein

the restricting member is a swing arm configured to switch between the locked state and the unlocked state by turning.

8. The charging port device for an electric vehicle according to claim 1, wherein

the restricting member is a swing arm configured to switch between the locked state and the unlocked state by turning.

9. A charging port device for an electric vehicle comprising:

a charging port having an engaged part configured to engage an engaging part of a charging connector, the charging port being configured to receive power from an external power supply when the engaging part and the engaged part are in an engaged state;

a restricting member that, when the engaging part and the engaged part are in the engaged state, regulates a release operation in which the engaging part separates from the engaged part, so as to restrict the engaged state from being released; and

a locking state control device configured to move the restricting member to produce a locked state and an unlocked state, the locked state being a state in which the engaged part and the engaging part overlap when viewed from a direction of separation and in which the release operation on the engaging part is restricted, the unlocked state being a state in which there is no overlap between the engaged part and the engaging member and in which the release operation is enabled,

the locking state control device having an electrical driving mechanism configured to electrically impart a torque using a motor to move the restricting member to an inner-side position near a predetermined position corresponding to one of the locked state and the unlocked state, and a mechanical driving mechanism configured to mechanically impart a torque to move the restricting member from the inner-side position to the predetermined position, when the restricting member is to be moved to the predetermined position, and

the restricting member including a part configured to overlap the engaging part when viewed from the direction of separation and when disposed at the inner-side position near the predetermined position corresponding to the locked state, and

the locking state control device having a dead zone in which the restricting member is not moved by the mechanical driving mechanism, and the restricting

16

member overlaps the engaging member, when viewed from the direction of separation, in the dead zone.

10. The charging port device for an electric vehicle according to claim 9, wherein

the locking state control device is configured to control the motor so that there is an overlap between a first region, in which the torque from the motor acts when the restricting member is being moved to the locked state, and a second region, in which the torque from the motor acts when the restricting member is being moved to the unlocked state, and

the dead zone is formed at a position that overlaps a region in which the first region and the second region overlap.

11. The charging port device for an electric vehicle according to claim 10, wherein

the mechanical driving mechanism is a toggle spring disposed between the restricting member and a vehicle body side.

12. The charging port device for an electric vehicle according to claim 10, wherein

the restricting member is a swing arm configured to switch between the locked state and the unlocked state by turning.

13. The charging port device for an electric vehicle according to claim 9, wherein

the mechanical driving mechanism is a toggle spring disposed between the restricting member and a vehicle body side.

14. The charging port device for an electric vehicle according to claim 9, wherein

the restricting member is a swing arm configured to switch between the locked state and the unlocked state by turning.

15. A charging port device for an electric vehicle, comprising:

a charging port having an engaged part configured to engage an engaging part of a charging connector, the charging port being configured to receive power from an external power supply when the engaging part and the engaged part are in an engaged state;

a restricting member regulating a release operation when the engaging part and the engaged part are in the engaged state, the release operation being an operation in which the engaging part separates from the engaged part; and

a locking state control device configured to move the restricting member across an actuation range from a locking position to an unlocking position, the locking state control device having an electrical driving mechanism and a mechanical driving mechanism,

the electrical driving mechanism being configured to electrically impart a torque using a motor to move the restricting member across a first portion of the actuation range, the first portion of the actuation range being smaller than the actuation range,

the mechanical driving mechanism being configured to mechanically impart a torque to move the restricting member across a second portion of the actuation range that is different from the first portion of the actuation range.

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